



# omatt

February 23, 2011

## Abstract

Convert a source list from OM detector to sky coordinates, and produce a sky coordinate OM OSW image

## 1 Instruments/Modes

Instrument	Mode
OM	FAST
OM	IMAGING

## 2 Use

pipeline processing	yes
interactive analysis	yes

## 3 Description

This task takes an OM OSW source list, with source positions in pixels, and converts to sky coordinates. These sky coordinates are then used to produce a sky coordinate image.

The task requires the user to enter the name of an OSW source list and its corresponding OSW image. The name of the output sky coordinate image must also be passed to the task, along with a tolerance parameter (see below).

The task first reads the binning factors (BINAX1 and BINAX2) from the FITS header, along with the BPE binning flag (TWIXEL) and the  $x$  and  $y$  size of the OSW window (in centroided pixels) along with the  $x$  and  $y$  offsets of the window. The pixel coordinates of the OSW source list are then converted to the PIXCOORD reference frame (2048 by 2048 centroided pixels).

The OM optics have a small amount of distortion, and the CAL call omDistortion is used to get the offsets of the pixel position from a linear scale. These offsets are then applied to the pixel positions. A CAL to GetPlateScale is subsequently used to convert from pixels to radians. (The center of the detector, i.e. the position of the OM boresight is pixel 1024.5, 1024.5).



The shift and add process is all performed relative to a reference frame (used to find the tracking stars), so a call to `OAL.getAttitude` is used, with the time of the reference exposure, to get the spacecraft attitude. The CAL Boresight routine is used to obtain the boresight offset matrix, which is applied to the s/c attitude to get the OM boresight direction, which is then rotated by the roll angle about the s/c boresight direction, as are the tangent plane coordinates. The tangent plane coordinates are then converted to sky coordinates.

The source positions, in RA and DEC, are then written to the source list, along with the positional error (the pixel coordinates are retained in the source list).

The second (optional) part of the task employs the USNO SA1 catalogue (if available) to correct the RAs and DEC of the sources for any difference between the nominal pointing direction of the satellite and the true one. The OM pointing vector and field of view are used as parameters to a search of the USNO, which lists all catalog stars in the field of view. The algorithm sets up a grid of offsets in the x and y directions to be used to match up stars in the source list to those in the catalogue. For each set of offsets a maximum likelihood parameter is computed, and the offsets with the maximum parameter value are taken to be the best offsets. If sufficient stars are matched then a least-squares fit is performed, to yield more accurate astrometry. The fit yields more accurate values for the offsets, and also any small rotation between the two coordinate systems. Error for the parameters are computed by Monte Carlo simulations, in which new data sets are generated and the parameters computed. The mean and standard deviations of all the fitted parameters from the simulations are computed, and the standard deviations are used as the errors. Corrected RA and DEC columns are added to the source-list file.

The final section of the code takes the OM OSW image and rotates and rebins it into sky coordinates. From SAS 9.0 onwards, the 16-bit **QUALITY** image is also rotated and added to the output sky-image file. For this image, instead of using an interpolation scheme to set each of its pixels, each pixel is set by checking bits 0 to 10 of the nine pixels of the unrotated-image centred at the interpolation point and setting the corresponding bit if any of those is set.

## 4 Astrometric correction

Because the **RA** and **Dec** of the **OM** pointing direction may not be exactly the same as the coordinates deduced from reference to a catalogue (differences of a few arcsecs in **RA** and **Dec** are typical), **omatt** allows the user to determine these shifts and correct the source positions.

If the task parameter **usecat** is set to true, and the parameter **catfile** is set to the name of the fits catalogue file (or it has the default name `usnocat.fit`), **omatt** will attempt to correct the computed source coordinates. The correction is deemed to be a success if the following criteria are met:

- A sufficient number of stars have been matched (if the number of input sources (n) is less than 30,  $\max(4, n/4)$ , otherwise 10).
- The computed offset errors are no greater than the value of the input parameter **maxradecerr** (arcsecs).
- The computed RMS residual value is no greater than the value of the input parameter **maxrmsres** (arcsecs).

If successful, the columns **RA\_CORR** and **DEC\_CORR** will contain the corrected RAs and DEC, respectively, the key-word **POSCOROK** will be set to **true** and the key-words **RAOFFSET**, **RAOFFERR**, **DEOFFSET**, **DEOFFERR**, **ROT\_CORR**, **ROT\_ERR**, **NMATCHES**, **RMSRESID** will contain the computed RA offset, RA offset error, DEC offset, DEC offset error, rotation, rotation error, the number of sources used in the astrometric fit and the root-mean-square residual of the fit,



respectively. If the fit was unsuccessful then **POSCORROK** will be set to **false** and the columns **RA\_CORR** and **DEC\_CORR** will be set equal to the uncorrected values.

The user can use the task parameters **maxradecerr** and **maxrmsres** to change the settings that decide if an astrometric fit is okay (**POSCORROK=true**) or not (**POSCORROK=false**).

Please note that from **SAS 7.2** the astrometric fit does not allow for any rotation between the **OM** and **USN0** coordinate axes, since the computed rotations were never more than a few arc minutes- hence **ROT\_CORR** will always be zero.

## 4.1 Catalogue file format

Unfortunately, at the present time no catalogue file is included with an ODF to enable a user to re-compute the astrometry correction. However, CB is happy to create the file for anybody, on request. The **catalogue** file has to be in **FITS** file format and contain the following columns in a **RAWRES** table.:

- **CAT\_RA**
- **CAT\_DEC**
- **CAT\_RADEC\_ERR**
- **BMAG**

## 4.2 Astrometric Columns

There are columns for the Right Ascension and declination, position error, **corrected** Right Ascension and Declination, galactic longitude and galactic latitude. The **corrected (RA\_CORR and DEC\_CORR)** columns refer to the Right Ascensions and declinations with the astrometric correction applied (if correction successful, **POSCORROK = TRUE**). If the correction wasn't successful (**POSCORROK = FALSE**) then these coordinates will be the same as the uncorrected ones.

## 5 Modification of Source-axes position angles

The position-angle of the major-axis of each source computed by **omdetect (PA)** is modified by **omatt** so that the angle is measured anti-clockwise from the North Pole.

## 6 Parameters

This section documents the parameters recognized by this task (if any).

Parameter	Mand	Type	Default	Constraints
<b>set</b>	yes	string	none	

OM image intermediate filename



<b>sourcelistset</b>	yes	string	none	
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OM OSW Source List filename

<b>ppsoswset</b>	no	string	none	
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PPS OM OSW FITS sky image filename

<b>usecat</b>	no	boolean	F	
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Use the USNO-SA 1 catalog

<b>catfile</b>	no	string	none	
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Name of the USNO-catalogue fits file for astrometry correction

<b>maxradecerr</b>	no	real	1.0	
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Maximum allowed RA/dec error in astrometry fit (arcsecs).

<b>maxrmsres</b>	no	real	1.5	
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Maximum allowed rms residual in astrometry fit (arcsecs).

<b>tolerance</b>	no	real	1.5	0.5:
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Tolerance to be used in source-matching (arcsecs).

<b>rotateimage</b>	no	boolean	T	
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Create the rotated sky-image

## 7 Errors

This section documents warnings and errors generated by this task (if any). Note that warnings and errors can also be generated in the SAS infrastructure libraries, in which case they would not be documented here. Refer to the index of all errors and warnings available in the HTML version of the SAS documentation.

### **diffBin** (*fatal*)

Different binning in x and y directions

### **Could not allocate memory for:** *name* (*fatal*)

Memory allocation for the named array failed



**Star catalogue not found- no astrometry correction done** (*warning*)

Too few sources for astrometry

*corrective action:*

**Need at least 10 stars to do a reliable correction** (*warning*)

noCat

*corrective action:*

**No stars in catalogue- catalogue has not been used to correct positions** (*warning*)

Cannot do astrometry

*corrective action:*

**No overlap between sources and catalogue stars** (*warning*)

Too few guide stars for astrometry correction

*corrective action:*

**Catalogue has not been used to correct positions** (*warning*)

Too few sources matched for astrometry

*corrective action:*

**Need at least 10 to do astrometry correction** (*warning*)

insuffData

*corrective action:*

**Insufficient number of data for least-squares fit** (*warning*)

singularSol

*corrective action:*

**singular solution to astrometric fit** (*warning*)

*corrective action:*

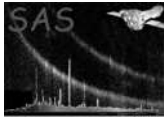
## 8 Input Files

1. OM OSW source list (as produced by OMDETECT/OMWAVELET)
2. OM OSW FITS image (as produced by OMMODMAP)

## 9 Output Files

1. OM OSW source list
2. PPS OM OSW FITS sky image.
3. if usecat=true a postscript file will be produced showing the goodness-of-fit of the astrometry correction.

## 10 Algorithm



```
open output file
read the OSW window parameters, binning factors from header

call CAL_GetBoresightMat
call OAL_GetAttitude (with time of reference frame)

find OM boresight direction
rotate by roll angle

loop over individual source information
  read in individual source information
  extract pixel position
  correct for distortion (CAL_omDistortion)
  call to CAL_omPlatescale to get linear plate-scale
  perform co-ordinate conversion
  (including s/c boresight offset correction and roll angle)
end loop
Add columns for the RA and dec of each source to the source-list file.

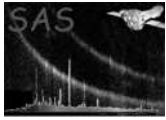
if (usecat) then
  read in the catalogue data.
  Set up a grid of offsets deltax and deltay in the x and y directions.
  Sort these offsets into increasing radius order from the origin.
  For each grid shift the stars by deltax and deltay in the x
  and y directions.
  Try to match each star with one in the catalogue by computing the
  distance between it and the selected catalogue stars and regarding
  it as matched if the distance is less than the specified tolerance.
  For each pair of offsets compute a maximum-likelihood parameter and take
  the pair with the maximum value as the best offsets.
  Use these offsets to repeat the star matching, and then perform a
  least-squares fit to improve the offsets and also determine any small
  rotation between the two coordinate systems.
  Determine errors on the computed parameters by a Monte Carlo procedure
  which generates artificial data sets from the original, computes the
  parameters for each simulation, and then at the end computes the mean and
  standard deviations of all the parameters.
  Correct the RAs and Dec of the sources using the computed parameters.
  Added corrected RA and Dec columns to the source-list file, and also
  information about the fit.

end if

Rebin, rotate and correct for distortion the image, and write out to a fits file.
Rebin, rotate and correct for distortion the 16-bit QUALITY image, and write out to the same fits file.

close OSWSL
close output file

end subroutine omatt
```



## 11 Comments

- none

## 12 Future developments

## References